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COMPLIANCE IS MANDATORY

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Chapter 3. Range Flight Safety

3.1 Introduction

Range flight safety considerations include three elements: range safety analysis, range safety systems, and operational requirements. This chapter provides a basic description of these elements and related concepts and provides the associated requirements. This chapter also provides requirements that apply to the qualification and training of personnel who perform range safety functions.

3.2 Range Safety Analysis

3.2.1 A vehicle program, in coordination with a Center range safety organization or the NASA Range Safety Manager, shall ensure that each range operation undergoes a range safety risk analysis to establish any design or operational constraints needed to control risk to persons or property (Requirement).

3.2.2 A Center range safety organization or the NASA Range Safety Manager shall review and approve the range safety risk analysis (Requirement).

3.2.3 A range safety risk analysis shall incorporate the elements of risk management; i.e., risk assessment, risk mitigation, containment, and risk acceptance (Requirement).

Note: Containment for the purposes of range safety is defined in Appendix A, and related requirements are in paragraph 3.2.9 of this NPR.

3.2.4 Range Safety Risk Management Process.

Note: The range safety risk management process is a specific implementation of the

general risk management approach defined in NPR 8000.4, Agency Risk Management Procedural Requirements.

3.2.4.1 A Center's or vehicle program's range safety risk management process shall include assessment of the risk to the public, workforce, and property in accordance with paragraph 3.2.5 of this NPR (Requirement).

3.2.4.2 A vehicle program's range safety risk management process shall incorporate the applicable requirements of any range, launch site, or landing site that supports the program's range operations (Requirement).

3.2.4.3 Within the range safety risk management process, the vehicle program, all cognizant range safety organizations, and the authority responsible for the range, launch site, or landing site shall coordinate with each other and with any other range users/tenants and public or private entities in the flight vicinity to:

a. Mitigate the risk to members of the public and the workforce (Requirement).

b. Identify any property in the vicinity of the flight that requires protection from potential debris impact and/or other hazards, identify the potential damage of concern, and mitigate the associated risk (Requirement).

Note: Local authorities and programs are responsible for determining what property requires protection. Local authorities may have risk management requirements that apply to certain high-value equipment, assets, or other property. There may be specific property for which the program requires risk management due to its proximity to the flight and the consequences associated with potential hazards.

c. Perform and document the risk assessment per paragraph 3.2.5 of this NPR (Requirement).

d. Make risk acceptance/disposition decisions that integrate concerns for public risk, workforce risk, risk to any property identified under paragraph 3.2.4.3.b, mission risk, including the risk to the safety of any flight crew, and mission constraints (Requirement).

e. Make operational decisions needed to control risk prior to initiation of flight or each phase of flight (Requirement):

(1) For an orbital RLV or vehicle that operates continuously for extended periods, the responsible organization(s) may make operational decisions, including the implementation of applicable per flight risk criteria, independently for each phase of flight (e.g., launch, entry, ascent, cruise, or descent) if all three of the following are satisfied:

(a) Each decision is based on a risk assessment that is conducted or revalidated just prior to each phase of flight.

(b) The assessment or revalidation accounts for updated vehicle status and updated predictions of flight conditions.

(c) The vehicle has sufficient controllability to allow for risk management as a prerequisite to beginning each phase of flight.

(2) For a mission that involves the operation of more than one vehicle simultaneously, the responsible organization(s) may make operational decisions, including the use of applicable per flight risk criteria, independently for each vehicle if each vehicle has sufficient independent controllability to allow the management of risk individually for the

flight of each vehicle.

f. Document decisions concerning approval of operations, acceptance/disposition of safety risk including justification, and the application of any additional safety controls or constraints based on safety evaluations (Requirement).

g. Inform all employees and visitors on NASA-controlled property of potential hazards associated with range operations and the actions to take in the event of an emergency (Requirement).

h. Manage any risk associated with planned and unplanned debris and/or potentially hazardous material that remains after impact (e.g., potential hazards to navigation due to floating debris, potential public exposure to explosive debris or toxic material, etc.) (Requirement).

3.2.4.4 The vehicle program shall develop and maintain formal documentation that provides the details of the vehicle program's range safety risk management process (Requirement).

Note: This documentation may take the form of a standalone plan or consist of a compilation of program documents such as tailored range safety requirements, ELS determinations, Range Safety Waivers, risk mitigation procedures, and launch/flight commit criteria. This documentation includes the risk management requirements and processes of any other organization that supports the program, such as the range, launch site, or landing site.

3.2.4.5 Risk Criteria. Each range operation shall satisfy the following criteria for assessed risk unless higher risk levels are specifically authorized for the operation (Requirement).

Note: The risk criteria within paragraph 3.2.4.5 of this NPR are consistent with RCC 321, Range Commanders Council Common Risk Criteria for National Test Ranges. RCC 321 and the RCC 321 Supplement contain background and justification for the risk criteria.

In general, these criteria define a level of assessed risk to the public, workforce, and property that the Agency accepts for all range operations without higher management review. If a range operation is to exceed any of these criteria, the Range Safety Waiver Process and associated requirements outlined in section 1.6 of this NPR apply.

Unless otherwise stated for a specific criterion, these criteria apply to the aggregate risk resulting from the combination of all hazards associated with a range operation.

In general, the risk criteria within paragraph 3.2.4.5 of this NPR apply per flight. They may be applied per phase of flight in accordance with paragraph 3.2.4.3.e of this NPR.

a. Individual Risk.

(1) Probability of casualty (P_C) $\leq 1 \times 10^{-6}$ for individual people who are not mission essential or critical operations personnel (Requirement).

(2) $P_C \leq 1 \times 10^{-6}$ for mission essential or critical operations personnel (Requirement).

Note: For purposes of consistency with DoD and FAA range safety policy, the

specific hazards considered in a range safety risk assessment are defined in paragraph 3.2.5.7 of this NPR.

b. Property Impact Probability. Probability of debris impact $\leq 1 \times 10^{-3}$ for any property identified under paragraph 3.2.4.3.b that could result in the damage of concern identified under paragraph 3.2.4.3.b, applied for each flight (Requirement).

c. Collective Risk.

(1) Collective Risk Criterion for the combination of Mission Essential Personnel and Critical Operations Personnel: Expectation of Casualty (E_C) $\leq 300 \times 10^{-6}$ (Requirement).

(2) Collective Public Risk Criteria: $E_C \leq 100 \times 10^{-6}$ (Requirement).

Note: Public includes all people who are not Critical Operations Personnel or Mission Essential Personnel and are on land, on waterborne vessels, and in aircraft. Range safety implementation of the EC criteria often includes the use of impact probability criteria, which ensure that any people on waterborne vessels or in aircraft do not contribute significantly to the overall public collective risk.

Space Shuttle: NASA has approved special collective public risk management provisions for the Space Shuttle that are in effect through the end of the Space Shuttle Program. Due to the established design and operational constraints, any significant alterations to Space Shuttle launch and entry operations would have the potential for negative effects on crew and mission. The special provisions allow the Space Shuttle Program to continue to use KSC as its primary launch and landing site, with Edwards Air Force Base and White Sands Missile Range as backup landing sites. The Space Shuttle Program, in coordination with NASA Headquarters, has quantified and thoroughly evaluated the risks associated Space Shuttle launches and landings. The public risk criteria, risk assessments, and risk management process for Space Shuttle are detailed in Space Shuttle Program and KSC documents which are available from the NASA Range Safety Manager upon request.

3.2.5 Range Safety Risk Assessment.

3.2.5.1 A range safety risk assessment shall be a formal documented analysis that identifies and characterizes risk for input to the risk management process (Requirement).

3.2.5.2 The risk assessment shall employ quantitative means unless all cognizant range safety organizations and other authorities agree that quantitative assessment is not necessary or not feasible; in which case the risk assessment shall employ qualitative measures (Requirement).

3.2.5.3 The risk assessment shall provide a best estimate of the risks and include an evaluation of uncertainty bounds or sensitivities to inputs (Requirement).

3.2.5.4 The assessment documentation shall identify all assumptions made (Requirement).

3.2.5.5 The risk assessment shall account for variability associated with the following:

a. Each source of hazard, including any associated with a payload, during flight (Requirement).

b. Normal flight and each appropriate foreseeable failure response mode of the vehicle

for each flight phase (Requirement).

c. Each appropriate foreseeable external and internal vehicle flight environment (Requirement).

d. Public and worker population potentially exposed to the flight (Requirement).

e. Population growth rates in order to remain valid if a risk assessment will apply to a number of flights over a number of years (Requirement).

f. The performance of any range safety system, control, or constraint including all associated time delays (Requirement).

3.2.5.6 Input data used for the range safety risk assessment shall include:

a. Vehicle reliability unless the vehicle will operate under full containment per paragraph 3.2.9 of this NPR (Requirement).

b. Proposed trajectories (nominal, preplanned contingency, abort, and malfunction trajectories) (Requirement).

c. Description of any landing sites and/or flight paths (Requirement).

d. Description of credible failure modes and their probability of occurrence resulting in a hazard to public safety (Requirement).

e. Reliability of any range safety system (Requirement).

f. All hazard controls and mitigation strategies (Requirement).

g. Pertinent vehicle information, such as size, weight, propellant types and amounts, and any explosives, pressurized vessels potential for high energy release, toxic materials, or radionuclides (Requirement).

h. Other relevant data required for analysis in support of specific mission objectives, including related payload information and data from pertinent lessons-learned reports (Requirement).

3.2.5.7 There are typically three types of hazards considered in a range safety risk assessment. These include debris, distant focusing overpressure, and toxic material release (see paragraphs 3.2.6, 3.2.7, and 3.2.8 respectively of this NPR).

a. A risk assessment shall account for the risk due to each hazard where applicable for each flight unless the hazard is fully contained (Requirement).

> *Note: Containment for the purposes of range safety is defined in Appendix A, and related requirements are in paragraph 3.2.9 of this NPR.*

b. Other hazards may exist based on specific mission requirements, and these hazards shall be included in the assessment on a case-by-case basis (Requirement).

3.2.6 Debris Risk Assessment.

3.2.6.1 A range safety analysis shall assess any risk due to debris for input to the risk management process (Requirement). For a launch, these requirements apply to any debris that does not achieve orbital insertion. For an entry operation, these requirements apply to any debris that might be generated, intentionally or not, after the deorbit burn or sample return capsule release. Any orbital debris is subject to the requirements of NPR

8715.6, NASA Procedural Requirements for Limiting Orbital Debris.

3.2.6.2 An assessment of risk to the public and workforce due to debris shall account for each of the following as a function of flight-time or loss-of-control-time:

a. All potential debris, generated intentionally or not, that could cause a casualty, including debris that could affect someone on the ground or on a waterborne vessel, or cause an aircraft accident (Requirement).

Note: Casualty models used in range safety risk assessments typically evaluate certain impact parameters, such as kinetic energy, and incorporate thresholds on those parameters that define when a debris impact has the potential to cause a casualty or down an aircraft. These thresholds may change as our knowledge of human vulnerability/aircraft vulnerability evolves. Sources of the latest casualty and aircraft impact thresholds developed for use by the range safety community include RCC 321, Common Risk Criteria Standard for National Test Ranges: Inert Debris, and AFSPCMAN 91-710, Range Safety User Requirements Manual.

b. All populated areas in the overflight area that could be impacted by the debris (Requirement).

c. The probability of the debris impacting each populated area, which accounts for the probability of vehicle failure (Requirement).

d. The effective casualty area of the impacting debris, which accounts for the cross-sectional area of the debris, average size of a person, and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact) (Requirement).

e. The population density of each populated area (Requirement).

Note: The assessment should consider any risk mitigation factors associated with each population, such as sheltering and time of day of the flight.

f. Debris variability, including size, shape, aerodynamic properties, weight, and potential to survive to impact (Requirement).

g. The sources of debris variability, including breakup conditions (Requirement).

h. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used (Requirement).

i. Any velocity imparted to the debris fragments during jettison, destruct, or breakup (Requirement).

j. The influence of atmospheric variability, including winds (Requirement).

3.2.6.3 A debris risk assessment for any property identified under paragraph 3.2.4.3.b shall account for:

a. All potential debris (intentionally or unintentionally generated) that could cause property damage, which accounts for the specific nature of the property (Requirement).

b. The cross-sectional area of the debris and the effects of any overpressure due to any explosive debris (debris that would explode on or after impact) (Requirement).

c. Debris variability, including size, shape, aerodynamic properties, weight, and potential

to survive to impact (Requirement).

d. The sources of debris variability, including breakup conditions (Requirement).

e. The uncertainties in the state vector at the instant of jettison or destruct and any correlations used (Requirement).

f. Any velocity imparted to the debris fragments during jettison, destruct, or breakup (Requirement).

g. The influence of atmospheric variability, including winds (Requirement).

h. The probability of the debris impacting the property, which accounts for the probability of vehicle failure and the location, size, and shape of the property (Requirement).

3.2.6.4 A range safety analysis shall establish launch/flight commit criteria (per paragraph 3.7.1 of this NPR) and operational constraints, such as hazard areas and impact limit lines, needed to control any risk due to debris impacts (Requirement).

3.2.6.5 A range safety analysis shall establish hazard areas needed to control risk due to debris including aircraft and ship hazard areas for notices to mariners and notices to airmen (Requirement).

3.2.7 Distant Focusing Overpressure Effects Risk Assessment.

3.2.7.1 A range safety analysis shall characterize the risk to the public and the workforce due to any distant focusing overpressure from potential explosions during vehicle operations for input to the risk management process (Requirement).

3.2.7.2 The analysis shall establish launch/flight commit criteria and operational constraints, such as hazard areas needed to control risk due to potential distant focus overpressure effects (Requirement).

3.2.7.3 A distant focusing overpressure analysis shall account for:

a. The potential for distant focusing overpressure or overpressure enhancement given current meteorological conditions and terrain characteristics (Requirement).

b. The potential for broken windows and related casualties (Requirement).

c. Characteristics of the potentially affected windows, including their size, location, orientation, glazing material, and condition (Requirement).

d. The hazard characteristics of the potential glass shards, such as falling from upper building stories or being propelled into or out of a shelter toward potentially occupied spaces (Requirement).

e. The explosive capability of the vehicle at or after impact and at altitude and potential explosions resulting from debris impacts, including the potential for mixing and ignition of liquid propellants, ignition of flammable propellants, and other propellant hazards, pyrotechnic and other explosive devices, and pressurized vessels with the potential for high energy release (Requirement).

f. Characteristics of the vehicle flight and the surroundings that would affect the population’s susceptibility to injury, for example, shelter types and time of day of the proposed activity (Requirement).

3.2.8 Toxic Hazard Risk Assessment.

3.2.8.1 In the case of a catastrophic failure of a vehicle in flight, the fire, explosion, reactivity, and safety hazards of propulsion and power fluids (e.g., hydrazines, nitrogen tetroxide, solid rocket motors fuels, and their combustion or decomposition products) may be released. Under certain meteorological conditions, high concentrations of these materials may drift over populated areas at levels greater than emergency health standards permit. As a result, NASA shall protect the public and workforce from toxic hazards using either hazard containment or a risk mitigation approach (Requirement). (For potential release of radioactive materials, see paragraph 3.4.)

3.2.8.2 A range safety analysis shall establish launch/flight commit criteria and operational constraints, such as hazard areas needed to control any risk due to potential toxic material release (Requirement).

a. The analysis shall assess any residual risk due to potential toxic material release not fully contained or mitigated for input to the program's risk management process (Requirement).

b. The analysis shall account for:

(1) Any foreseeable toxic material release during the proposed flight or in the event of a mishap (Requirement).

(2) Any operational constraints and emergency procedures that provide protection from toxic material release (Requirement).

(3) All populations potentially exposed to any toxic material release, including all members of the public and workforce on land and on any waterborne vessels and aircraft (Requirement).

(4) Potential emissions from both nominal range operations and catastrophic events to ensure response actions are designed to prevent or mitigate possible exposures (Requirement).

3.2.8.3 Centers and vehicle programs shall take actions to protect people when an airborne toxic material released in a nominal or aborted launch/flight may produce concentrations above applicable Federal and local response guidelines identified or established by the cognizant range safety organization (Requirement).

Note: Sources of toxic material release response guidelines include: American Industrial Hygiene Association - Emergency Response Planning Guidelines (ERPG), Occupational Safety and Health Administration - Permissible Exposure Limit (PEL), American Conference of Government and Industrial Hygienists - Threshold Limit Value (TLV), and Environmental Protection Agency - Acute Emergency Guidance Level (AEGL).

3.2.9 Containment.

3.2.9.1 When controlling risk through containment, the range safety analysis shall provide the basis for establishing the geographical areas from which people and any property identified under paragraph 3.2.4.3.b are to be excluded during flight (Requirement).

3.2.9.2 The analysis shall determine any operational controls needed to isolate each hazard and prevent/mitigate the risk due to the hazard (Requirement).

3.2.9.3 All cognizant range safety organizations, in conjunction with the program, shall establish the containment criteria for normal and malfunctioning vehicle flight (Requirement).

3.2.9.4 Any residual risk due to any hazard not fully contained shall undergo the risk management process of paragraph 3.2.4 (Requirement).

3.2.10 Risk Mitigation.

3.2.10.1 When controlling risk through mitigation, a range safety analysis shall establish the operational constraints that negate the risk or reduce it to a level that is acceptable with appropriate management approval (Requirement).

3.2.10.2 Any residual risk not fully mitigated shall undergo the risk management process of paragraph 3.2.4 (Requirement).

3.3 Range Safety Systems

3.3.1 Flight Termination System (FTS).

3.3.1.1 Each vehicle program shall implement an FTS that is fully compliant with the requirements of this NPR unless the flight risks are controlled through other means of containment and/or risk mitigation per the policy and requirements of paragraphs 1.2.2, 3.2.9, and 3.2.10 of this NPR that are approved by the cognizant Center range safety organization or NASA Range Safety Manager (Requirement).

Note: NPR 8705.2, Human-Rating Requirements for Space Systems, contains requirements that apply when a Range Safety Destruct System (i.e., a form of FTS) is used on any component of an inhabited vehicle. When designing future inhabited aerospace vehicles, the program should consider vehicle designs, operational characteristics, procedures, and controls that negate the need for an FTS; e.g., controllability and high reliability, fuels, materials, pressurized or explosive components, and trajectories for launch and entry that limit exposure of populations to hazards. Based on a case-by-case assessment, an inhabited vehicle might incorporate an FTS only on certain components and not on the inhabited portion of the vehicle. Vehicle programs should evaluate the need for an FTS to provide the ability to terminate thrust without destroying (i.e., exploding) the vehicle as a distinct action. This ability may be critical to support crew survivability and may allow for the establishment of termination criteria/rules that provide significant reductions in risk to people or property on the ground.

3.3.1.2 An FTS shall satisfy the requirements of AFSPCMAN 91-710, Range Safety User Requirements Manual or RCC 319, Flight Termination Systems Commonality Standard (Requirement).

Note: Under the grandfathering provisions of AFSPCMAN 91-710, some existing vehicle programs are governed by Eastern and Western Range (EWR) 127-1, Range Safety Requirements, which is the predecessor to AFSPCMAN 91-710. NASA accepts this grandfathering where applicable.

3.3.1.3 When an FTS is used for a NASA or NASA-sponsored vehicle, the vehicle program shall implement a secure FTS in accordance with NPR 2810.1, Security of Information Technology (Requirement).

3.3.1.4 Criteria for activation of the FTS for uninhabited vehicles shall include conditions for when:

a. Valid data shows the vehicle violating a flight termination boundary, unless other documented mitigations are in effect (Requirement).

b. Vehicle performance or location is unknown, the vehicle is capable of violating a flight termination boundary, and terminating flight would mitigate the risk (Requirement).

c. There is a gross trajectory deviation or obvious erratic flight rendering the vehicle uncontrollable (Requirement).

d. Other mission-specific conditions present rationale for additional criteria (Requirement).

3.3.1.5 When an inhabited vehicle or its launch systems require an FTS, the cognizant Center range safety organization or the NASA Range Safety Manager and the program shall coordinate to develop the flight termination activation criteria (Requirement). NPR 8705.2, Human-Rating Requirements for Space Systems, applies.

3.3.2 Autonomous Flight Safety System (AFSS).

Note: Autonomous in this context is defined as events or actions which occur without ground-based intervention during flight and may include flight termination for range safety purposes. NASA continues to coordinate with the Air Force and other members of the national range community to further develop and implement AFSS for space launch and other range operations, to include development of related range safety requirements.

3.3.2.1 AFSS may be used for NASA range operations where the implementation meets vehicle and operational constraints and the system is designed and qualified to standards approved by the cognizant Center range safety organization or the NASA Range Safety Manager.

3.3.2.2 For human spaceflight, the primary purpose and operational concept for any flight safety system, including AFSS, is to protect the public while maximizing the likelihood of crew survival. To assure crew safety, any AFSS concept employed shall provide failure tolerance to catastrophic events per NPR 8705.2, Human-Rating Requirements for Space Systems (Requirement). The design and implementation of a human-rated AFSS may be highly specific to the human spaceflight vehicle and may incorporate, or work in conjunction with, unique aspects of the vehicle systems as appropriate.

Note: The Space Shuttle Program will use existing range safety tracking and ground-based command systems through program fly out.

3.3.3 Recovery Systems and Contingency Management Systems (CMS).

3.3.3.1 A Recovery System or CMS may use a set of elements within the vehicle, including but not limited to, manual control or autonomous control. A Recovery System or CMS may also include elements that are independent of the vehicle.

3.3.3.2 A Recovery System or CMS may provide for deliberate termination of an errant/erratic vehicle's flight but shall not be considered an FTS unless the system meets the requirements of paragraph 3.3.1 of this NPR and the related tracking, telemetry, and

command requirements of paragraphs 3.3.4.1, 3.3.5.4, and 3.3.6 of this NPR (Requirement).

3.3.3.3 A Recovery System or CMS that does not meet FTS requirements may be considered as risk mitigation and factor into the range safety risk assessment for the range operation where applicable.

3.3.3.4 Activation of a Recovery System or CMS shall not increase the risk to people or property (Requirement).

3.3.4 Vehicle Tracking.

3.3.4.1 For a vehicle that is flown with an FTS:

a. The range safety systems used to support a flight termination decision shall include at least two sources of vehicle tracking data, where the two sources are independent of each other and at least one of the sources is independent of the vehicle guidance system (Requirement).

b. The tracking data from each source shall be of sufficient quality to determine the vehicle's real-time position and instantaneous impact point throughout the period of time that the data is needed to support a flight termination decision (Requirement).

Note: For orbital vehicles, this tracking time period includes launch through the time that tracking and command capability is needed to protect the public from hazards of vehicle flight. This tracking time period is throughout the mission for suborbital or aeronautical vehicles and upon entry through landing for entry vehicles. The tracking time period may consider operational constraints. For example, for a launch, the tracking may not be needed immediately at liftoff as long as it will be available prior to the earliest time that the vehicle could endanger people or property.

3.3.4.2 For the flight of an uninhabited vehicle that is flown without an FTS, the range safety system shall include tracking or other data sources sufficient to determine the impact footprint of all vehicle components (Requirement).

Note: Most ranges that support NASA missions have local vehicle tracking requirements that apply (e.g., Air Force range safety vehicle tracking requirements are outlined in Air Force Space Command Manual 91-710).

3.3.5 Telemetry.

3.3.5.1 All data systems that provide information used to evaluate range safety requirements shall undergo validation to ensure operational readiness prior to initiating any phase of flight such as launch or entry (Requirement).

3.3.5.2 The range safety telemetry system shall provide continuous, accurate data during preflight operations and during flight (Requirement).

3.3.5.3 The vehicle program shall coordinate with all cognizant range safety organizations to identify the safety data required for each flight (Requirement).

3.3.5.4 For a vehicle that uses an FTS, the telemetry data shall include parameters that describe the health and status of the FTS and the vehicle needed to support a flight termination decision (Requirement). These parameters may include:

a. FTS:

(1) Receiver signal strength, command, and pilot tone or check channel status.

(2) Safe/arm status.

(3) Battery voltage.

(4) Battery temperature.

b. Navigation system parameters such as position, velocity, and acceleration.

c. Guidance commands including nozzle deflections in the pitch and yaw axes.

d. Vehicle attitude data including pitch, yaw, and roll angles and rates.

e. Engine chamber pressures.

f. Indicators of separation and/or jettison events.

g. Global positioning system positional and velocity data, when used for range safety purposes.

Note: Most ranges that support NASA missions have local telemetry requirements that apply (e.g., Air Force range safety telemetry requirements are outlined in Air Force Space Command Manual 91-710).

3.3.6 FTS Command System.

3.3.6.1 An FTS command system used to support missions that require an FTS shall incorporate fully redundant and independent command paths (Requirement).

3.3.6.2 An FTS command system shall undergo validation to ensure operational readiness prior to every mission (Requirement).

3.3.6.3 FTS command systems shall be under configuration control (Requirement).

3.4 Radiation Systems

NASA Centers and programs with range operations that use radiation sources (e.g., radio-frequency/microwave emitters, radioactive materials, X-ray devices, lasers, and optical emitters) are subject to the requirements of NPR 1800.1, NASA Occupational Health Program Procedures, Chapter 4, and local range requirements. NPR 8715.3, NASA General Safety Program Requirements, Chapter 6, contains requirements and guidance applicable to space launch of radioactive materials.

3.5 Laser Hazard Controls

NASA range operations involving the use of lasers are subject to the requirements of NPR 1800.1, Chapter 4, and local range requirements.

Note: This includes required assessment and approval by NASA laser safety officials, coordination with the FAA for lasers entering the National Airspace, and coordination with the DoD Laser Safety Clearinghouse for lasers with the potential to strike orbiting satellites.

3.6 Safety-Critical Software

Vehicle programs and range safety organizations shall identify safety-critical software in range safety systems owned by NASA or used to support NASA missions and ensure it satisfies NPR 7150.2, NASA Software Engineering Requirements, and NASA STD 8719.13, Software Safety (Requirement).

3.7 Operational Requirements

3.7.1 Launch/Flight Commit Criteria.

3.7.1.1 The launch/flight commit criteria for a range operation shall identify the conditions required to initiate each flight or phase of flight (see paragraph 3.2.4.3.e.1 for requirements that apply to phases of flight) (Requirement).

3.7.1.2 The launch/flight commit criteria shall provide for:

a. Assurance that the collision avoidance requirements of paragraph 3.7.3 are satisfied for any launch or entry (Requirement).

b. Surveillance of any established hazard areas (Requirement).

c. Verification that all range safety systems are available and operational (Requirement).

d. Verification that the meteorological conditions, such as wind and visibility, are within the limits defined by the range safety analysis (Requirement).

e. Verification that natural and triggered lightning constraints are within limits (requirement).

f. Verification that the range safety risk criteria are satisfied including any specific range safety risk constraints (Requirement).

3.7.1.3 Implementation of the launch/flight commit criteria shall include documenting the actual conditions at the time of flight or time of each phase of flight where applicable to verify that the launch/flight commit criteria have been met (Requirement).

3.7.2 Entry Operations.

An entry operation that is primarily for mission purposes other than disposal begins with the final commitment to entry and landing (e.g., the final command that initiates or enables the entry and landing sequence or the final decision point to allow the entry to proceed) and ends when all vehicle components associated with the entry come to rest on the Earth (including any jettisoned components).

> *Note: NPR 8715.6 contains requirements for limiting orbital debris generation, including requirements that apply to entry for the primary purpose of disposal, such as controlled or uncontrolled entry of spent launch vehicle upper stages after orbital insertion or orbital spacecraft that have completed their mission.*

3.7.2.1 Entry and landing shall not be committed until the vehicle program confirms that all conditions critical to safety are met (Requirement).

3.7.2.2 The entry phase of a vehicle program's risk management process, including the vehicle's reliability to achieve controlled entry to the targeted landing site or debris footprint, shall be approved by the cognizant Center range safety organization or the NASA Range Safety Manager prior to launch (Requirement).

Note: The intent is to provide assurance that the vehicle will be deorbited in a predictable manner that allows for appropriate risk management for the entry operation in accordance with paragraph 3.2.4. of this NPR.

3.7.3 Collision Avoidance (COLA).

3.7.3.1 During launch and entry operations, the space vehicle program, in coordination with all cognizant range safety organizations, shall ensure that the vehicle, any jettisoned component, and/or payload meets one of the following criteria with regard to all orbital inhabited or inhabitable spacecraft (Requirement):

a. Spherical volumes greater than or equal to 200 kilometers; OR

b. An ellipsoidal miss distance greater than or equal to 200 km in-track and 50 km cross-track or radially; OR

c. A probability of impact less than or equal to 1 × 10-6.

Note: A program or range organization may set additional criteria to protect against collision with other orbiting spacecraft or objects. These criteria may also be appropriate for use during on-orbit maneuvers. Example: NASA launches from an Air Force range are subject to Air Force Instruction 91-217, Space Safety and Mishap Prevention Program, which provides criteria for protection of active satellites in addition to inhabited/inhabitable spacecraft.

3.7.3.2 The vehicle program designated range safety representative or cognizant range safety organization shall:

a. Inform the United States Strategic Command of an upcoming launch or entry operation at least 15 days before the operation (Requirement).

b. Notify the United States Strategic Command immediately of any change in the planned launch or entry operations that occurs after the initial notification (Requirement).

c. Obtain a COLA analysis from the United States Strategic Command or perform an equivalent analysis needed to satisfy paragraph 3.7.3.1 of this NPR (Requirement). The COLA analysis shall:

(1) Establish each wait in a planned launch/entry window during which the vehicle program will not initiate or commit to launch/entry in order to satisfy the criteria of paragraph 3.7.3.1 of this NPR and any program or range specific criteria (Requirement).

(2) Account for the vehicle, any jettisoned component, and/or payload achieving altitudes greater than 150 km (Requirement).

(3) Account for uncertainties associated with vehicle performance and timing and ensure that any calculated launch/entry waits incorporate all additional time periods associated with such uncertainties (Requirement).

(4) For an orbital launch, account for ascent to orbital insertion plus a number of revolutions that: (i) accounts for each objects' orbit type, (ii) accounts for each objects altitude in relation to each other as needed to satisfy the applicable criteria, and (iii) provides sufficient time for each new orbital object to be catalogued by United States Strategic Command (Requirement).

(5) For a suborbital launch, account for the entire flight to landing or final impact

(Requirement).

Note: The COLA analysis need not account for an inhabitable orbital object if the three-sigma maximum altitude capability of the launch vehicle, any jettisoned component, and/or payload is 50 km or more below the orbital perigee of the inhabitable object.

(6) For an entry operation, account for the entry trajectory from the point that deorbit is committed through landing or final impact (Requirement).

d. Implement launch/entry waits as launch/flight commit criteria per paragraph 3.7.1 of this NPR and any other constraints needed to satisfy paragraph 3.7.3.1 of this NPR (Requirement).

3.7.4 Unmanned Aircraft Systems (UAS) Operations. NASA UAS operations are subject to the requirements of NPR 7900.3, Aircraft Operations Management, Chapter 5, and the applicable range safety requirements and methodologies of this NPR.

Note: RCC 323, Range Safety Criteria for Unmanned Air Vehicles and RCC 555, User Guide for Unmanned Aerial System Operations on the National Ranges provide additional guidance for organizations hosting or sponsoring a UAS operation.

3.7.5 Aerostat/Balloon Systems Operations. Each vehicle program involved in operating an aerostat or balloon (this includes hosting or sponsoring an aerostat or balloon operation) is subject to 14 CFR, 101: Aeronautics and Space, Part 101 - Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons.

Note: Guidance for operating an aerostat or balloon in special use airspace can be found in Air Force Space Command Manual 91-710.

3.8 Range Safety Personnel Qualifications and Training

3.8.1 Qualifications for personnel who perform a range safety function for a NASA range operation (including RSOs and personnel responsible for range safety systems and range safety analysis) shall include:

a. Successful completion of knowledge-based training (self-study and/or classroom) applicable to the range safety function (Requirement).

b. Successful completion of instructor-led, hands-on training on how to perform the range safety function followed by satisfactory on-the-job performance as a trainee, as applicable (Requirement).

c. Proficiency demonstrated to a qualified range safety professional during simulation scenarios that exercise hands-on operations of range safety systems and use of safety decision-making tools or processes, as applicable (Requirement).

d. Proficiency demonstrated to a qualified range safety professional during exercises of nominal and contingency actions, as applicable (Requirement).

3.8.2 The training program for range safety personnel who support NASA range operations shall:

a. Provide qualified personnel to support nominal and contingency range operations (Requirement).

b. Include a recurring training process to ensure personnel retain their qualifications (Requirement).

c. Include a requalification process for personnel who lose qualification status, such as someone who exhibits substandard performance or has health problems (Requirement).

d. Include a documentation process that captures the qualification, recurring training, and requalification status of all range safety personnel (Requirement).

3.8.3 RSOs with real-time safety decision-making responsibility (including FTS command responsibility) shall meet the safety certification requirements of NPR 8715.3, paragraph 7.4.6, in addition to the requirements of this NPR (Requirement).

Note: NPR 8715.3, paragraph 7.4.5 lists RSOs under Hazardous Operations Requiring Safety Certification. Not all RSO functions involve real-time operations. The focus of the safety certification requirements in NPR 8715.3, paragraph 7.4.6 (including physical examination) is on RSOs with real-time safety decision-making responsibility.

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